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Preliminary Mechanical Design of FHX for PGSFR

Jin-yup Choo [a*], G.H Koo, S.K Kim
[a] *Korea Atomic Energy Research Institute*
111, Daedeok-daero989beon-gil, Yuseong-gu, Daejeon 305-353 Republic of Korea
[*]*Corresponding author: cjy@kaeri.re.kr*

1. Introduction

The Forced-draft sodium-to-air Heat Exchanger system (FHX) (employed in the Active Decay Heat Removal System (ADHRS) is a shell-and-tube type counter-current flow heat exchanger with serpentine finned-tube arrangement. Liquid sodium flows inside the heat transfer tubes and atmospheric air flows over the finned tubes. The configuration and overall shape of the unit are shown in the Fig. 1. The unit is placed above the reactor building and has function of dumping the system heat load into the final heat sink, i.e., the atmosphere. Heat is transmitted from the primary hot sodium pool into the ADHRS sodium loop via Decay Heat Exchanger (DHX), and a direct heat exchange occurs between the tube-side sodium and the shell-side air through the FHX sodium tube wall.

Cold atmospheric air is introduced into the air inlet duct at the lower part of the unit by using an electrically driven air blower. Air flows across the finned tube bank rising upward direction to make uniform air flow with perfect mixing across the tubes. The finned tube bundle is placed inside a well-insulated casing. The air heated at the tube bank region is collected at the top of the unit and then is discharged through the air stack above the unit. Although a blower supplies atmospheric air into the FHX unit, a tall air stack is also provided to secure natural draft head of natural circulation air flow against a loss power supply. The stack also has rain protecting structures to prevent inflow of rain drops or undesired harmful objects.

To place this FHX tube assembly on the SFR, the housing is necessary. FHX`s specific tube bundle dimensions have already deducted by analysis. In this paper, more specific data from analysis and mechanical method of approach to design will be addressed. Especially, frame of tube bundle and housing of FHX.

Fig. 1. 3D Model of FHX

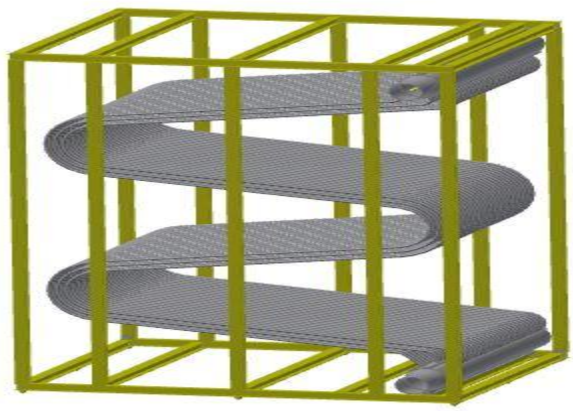

Fig. 2. FHX tube bundle assembly

2. Tube module and frame connecting method

To build a frame structure supporting the bundle assembly, 100mm by 100mm Korean Standard [1] H-beams are used. Each H-beam is connected by the Bracket with bolt and nut, and weld over. Three types of Bracket are used to connect to each H-beams. Bracket type 1 (Fig. 3) is placed on the rectangular connecting part. And every bolts and nuts are welded with Brackets. Bracket type 2 (Fig. 4) is put on the inside rectangular part between this Bracket tube supporting plate will be placed. These parts will be assembled same way of Bracket type 1`s. Bracket type 3 (Fig. 5) is arranged on width direction connecting point. Because of the H-beam`s characteristic of structure, there is the web that is in the middle of H-beam`s flange. Therefore, longer Bracket should be necessary. The joint like Bracket type 3 is needed to connect width direction. This type is assembled also like above method.

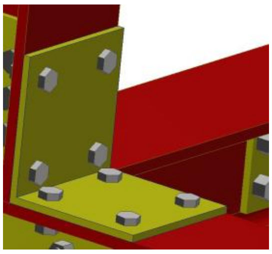
Fig. 3. Bracket type1

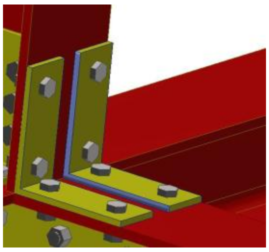
Fig. 4. Bracket type2

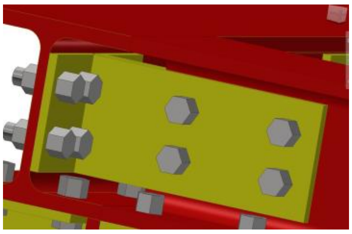
Fig. 5. Bracket type 3

3. Supporting method of FHX tube bundle assembly on the housing

Whole module is around 1.4tons, so it is possible that just put on the support in the housing. However, because of vibration and when it occurs seismic, Lug (Fig.6) is necessary. Total 6 Lugs are attached on the bottom of the H-beamed frame uniformly by welding. At the same location of Lugs, there are 6 grooves on the support. Lugs are inserting to the grooves.

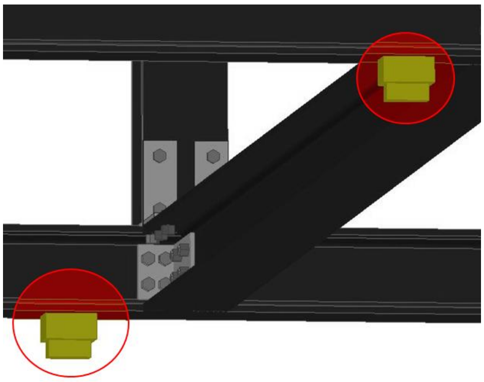
Fig. 6. Lugs(inside red circle)

4. Assemble the Housing

Housing consists of Stack, Case, Module Support, Supporting leg and Duct. Total height is over 30m. To assemble this housing of great dimensions, just welding can be bring about collapse. Therefore bolting assemble method is needed to endure a wobble. In the Fig.7 there are flanges round each part`s end with bolting holes. From these holes, every part connects each other with bolt, nut and spring washer. Especially Duct, to assemble with housing from beneath, bolts and spring washers are needed

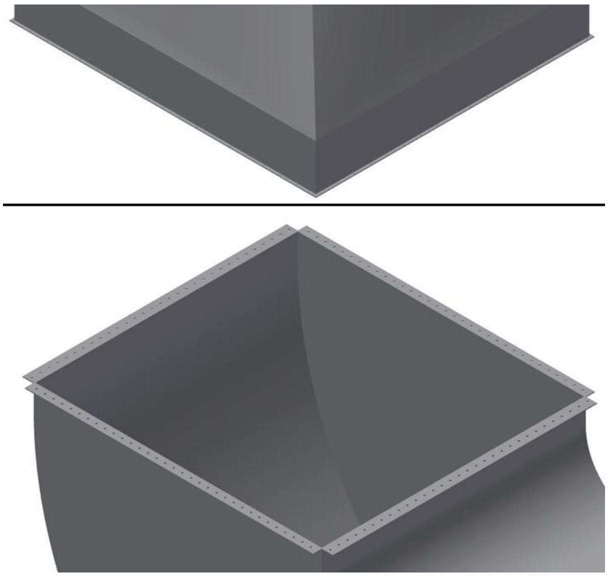
Fig. 7. Flanges of FHX housing

5. Case door design

To examine and fix inside of FHX such as tube bundle, particular design is needed. Therefore, we designed Case Door. Front side of FHX case, there are flanges both side like Fig. 10. Case door in the Fig. 9, there are two holes to let sodium pipe to tube bundle go by. Case and Case Door are assembled with bolts and spring washers. When we want to check tube bundle, we have to loosen bolts and open the door.

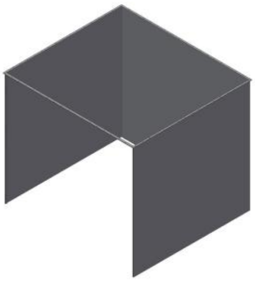

Fig. 8. FHX case

Fig. 9. Case door

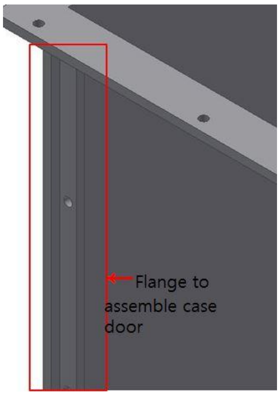

Fig. 10. Flange to assemble case door

6. Conclusions

Heretofore, it is concept design by mechanical basic knowledge and research of various structures that are activating in realities. Especially, to reduce thermal stress, we have planning to attach insulations inside the housing. Inasmuch as FHX is as important on SFR as the other part, hereafter, we will develop FEM to check feasibility of the FHX`s housing design in order to perform static and thermal analysis as well as bucking, seismic and so on.

REFERENCE

[1] “Dimension, mass and permissible variations of hot rolled steel section”(KS D 3502)